§5. Potential Measurement by 6 MeV Heavy Ion Beam Probe on LHD

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A heavy ion beam probe (HIBP) is a unique diagnostic technique to measure the electrostatic potential, its fluctuation and density fluctuation directly and simultaneously in high temperature plasmas. Hitherto, HIBPs have been applied for various magnetically confined plasmas and they have obtained significant results related to transport physics in plasmas. The radial electric field is recognized to be one of key parameters for the transport in Large Helical Device (LHD). Thus, we have developed an HIBP for LHD. The installation of the whole system has been recently completed, and the probing beam was detected and its energy was analyzed successfully[1) 2)]. In this report, results of the potential measurement are described.

The plasma potential has been measured during neutral beam injection (NBI) heating. The magnetic field strength is 2.75 T, and the major radius of the magnetic axis is 3.6 m. The beam energy of the HIBP is set to 5.042 MeV. According to the trajectory calculation, which is provisional, the potential profile can be measured within the normalized radius (ρ) of about 0.2 during the sweep of the probing beam (Fig. 1 (a)).

The waveforms are shown in Fig. 1 (b). The plasma is produced by electron cyclotron heating (ECH) and sustained by co- and counter-NBI with the total power of 7.0 MW.

The measured profile of the plasma potential is shown in Fig. 1 (c). The potential tends to become positive by about 2 kV during NBI. The result suggests that the radial electric field (E_r) of the electron-root is formed predominantly in the plasma. The E_r at the plasma edge is measured by charge exchange spectroscopy (CXS), and the positive E_r is observed. The positive potential measured by the HIBP is qualitatively consistent with the positive E_r measured by the CXS. The HIBP measurement is limited around the plasma center because the probing beam is blocked by the vacuum vessel, and the CXS can not measure at the plasma center in this magnetic configuration because of the low emission. Thus, the data measured by the HIBP and CXS are not craosschecked, yet. But, they can probably measure at same magnetic surface when the major radius of the magnetic axis is 3.9 m, so they will be crosschecked quantitatively in the magnetic configuration in future.

A serious problem related to the potential measurement remains. During ECH, the secondary beam profile changes drastically, even though the density and temperature profiles do not change. Judging from the behavior of the secondary beam profile, the probing beam seems to shift, though the sweep voltages are constant. One of possible causes is that the acceleration voltage and the applied voltage in the beam line components change because of the voltage-drop of the power supply during the ECH. The cause must be clarified and be solved in order to measure the behavior of the potential in the plasma accurately.

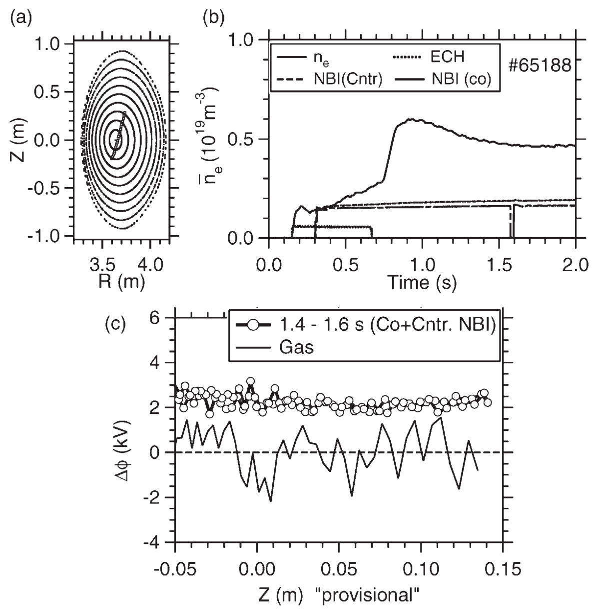

Fig. 1 (a)The magnetic surface and the calculated position of the sample volumes. Note that the calculation is provisional. (b)Line averaged electron density and timing of NBI and ECH. (c) Measured potential profile in balance-NBI plasma. The horizontal axis is the position of the measurement and it is provisional. The solid curve indicated as "Gas" is the potential of the vacuum vessel.

Reference
1) Ido, T., et al.: submitted to Rev. Sci. Instrum (2006)
2) Shimizu, A., et al.: in this Annual report